

I claim:

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1. An exercise apparatus, comprising:
a frame; and
left and right pedals interconnected to the frame;
wherein each of the left and right pedals is adapted to be moved in any one
of the following ways:

- (1) in a substantially vertical direction;
(2) in a substantially horizontal direction; and
(3) simultaneously in a substantially vertical direction and a
substantially horizontal direction.

2. The exercise apparatus of claim 1, further comprising a pedal
support assembly configured to interconnect each of the pedals to the frame.

3. The exercise apparatus of claim 2, wherein the pedal support
assembly further includes a horizontal guide assembly configured to permit each
of the pedals to be moved in a substantially horizontal direction.

4. The exercise apparatus of claim 3, wherein the horizontal guide assembly further includes:

a pair of guides, each guide being coupled to a respective pedal; and

a pair of roller assemblies, each roller assembly being coupled to a respective guide and configured to enable the pedals to move in a substantial horizontal direction.

5. The exercise apparatus of claim 4, wherein each pedal is slidingly mounted to a respective guide by a respective roller assembly.

6. The exercise apparatus of claim 4, wherein the pedal support assembly includes an upright support, and wherein each of the guides is slidingly mounted to the upright support by a respective roller assembly, and the pedals are fixedly mounted to the guides.

7. The exercise apparatus of claim 2, wherein the pedal support assembly further includes a vertical guide assembly configured to permit the pedals to be moved in a substantially vertical direction.

8. The exercise apparatus of claim 7, wherein the vertical guide assembly further includes:

a plurality of rollers;

upright supports coupled to the frame having substantially vertical channels sized to accommodate the rollers; and

roller mounts configured to support the rollers.

9. The exercise apparatus of claim 8, wherein the roller mounts are coupled to a horizontal guide assembly.

10. The exercise apparatus of claim 2, wherein the pedal support assembly further includes a motion translation mechanism adapted to link each of the pedals for reciprocal motion.

11. The exercise apparatus of claim 10, wherein the motion translation mechanism further includes a vertical motion translation linkage adapted to link each of the pedals for reciprocal motion in a substantially vertical direction.

12. The exercise apparatus of claim 11, wherein the vertical motion translation linkage includes a rack and pinion.

13. The exercise apparatus of claim 11, wherein the vertical motion translation linkage further includes a flexible tensile member interconnecting the vertical motion of each of the pedals.

14. The exercise apparatus of claim 13, wherein the flexible tensile member is selected from the group consisting of a rope, belt, toothed belt, chain, and cable.

15. The exercise apparatus of claim 11, wherein the vertical motion translation linkage further includes a chain and sprocket assembly.

16. The exercise apparatus of claim 10, wherein the motion translation mechanism further includes a horizontal motion translation linkage adapted to link each of the pedals for reciprocal motion in a substantially horizontal direction.

17. The exercise apparatus of claim 16, wherein the horizontal motion translation linkage includes a rack and pinion.

18. The exercise apparatus of claim 16, wherein the horizontal motion translation linkage further includes a flexible tensile member interconnecting the horizontal motion of each of the pedals.

19. The exercise apparatus of claim 18, wherein the flexible tensile member is selected from the group consisting of a rope, belt, toothed belt, chain, and cable.

20. The exercise apparatus of claim 16, wherein the horizontal motion translation linkage includes a pulley and belt assembly.

21. The exercise apparatus of claim 20, wherein the pulley and belt assembly further includes a shaft configured to transmit rotational motion.

22. The exercise apparatus of claim 21, wherein the horizontal motion translation linkage further includes at least one sliding bearing configured to slide along the shaft.

23. The exercise apparatus of claim 22, wherein the sliding bearing is a ball spline bearing.

24. The exercise apparatus of claim 10, wherein the motion translation mechanism further includes a resistance subsystem configured to apply selectively a resistance force to act against the motion of each of the pedals.

25. The exercise apparatus of claim 24, wherein the resistance subsystem further includes a horizontal motion resistance mechanism coupled to a horizontal motion translation linkage of the motion translation mechanism, wherein the horizontal motion resistance mechanism is configured to apply a resistance force to act against horizontal motion of each of the pedals.

26. The exercise apparatus of claim 25, wherein the horizontal resistance mechanism includes a friction brake.

27. The exercise apparatus of claim 25, wherein the horizontal resistance mechanism includes an electro-magnetic motor.

28. The exercise apparatus of claim 25, wherein the horizontal resistance mechanism includes a hydraulic cylinder.

29. The exercise apparatus of claim 24, wherein the resistance subsystem further includes a vertical motion resistance mechanism coupled to a vertical motion translation linkage of the motion translation mechanism, wherein the vertical motion resistance mechanism is configured to apply a force to act against the vertical motion of each of the pedals.

30. The exercise apparatus of the claim 29, wherein the vertical motion resistance mechanism includes a friction brake.

31. The exercise apparatus of the claim 29, wherein the vertical motion resistance mechanism includes an electro-magnetic motor. *db*

32. The exercise apparatus of claim 29, wherein the vertical motion resistance mechanism includes a hydraulic cylinder. *db*

33. The exercise apparatus of claim 24, further comprising, a controller configured to selectively adjust resistance applied by the resistance subsystem. *not shown*

34. The exercise apparatus of claim 33, wherein the controller further includes at least one manual control operatively linked to the resistance subsystem configured to adjust the resistance applied. *GW*

35. The exercise apparatus of claim 33, further comprising:
a position encoder configured to sense the position of the pedals; and
an electronic controller configured to receive the position of the pedals and apply resistance to the pedals via the resistance subsystem, based on the sensed motion and/or position of the pedals. *103*

36. The exercise apparatus of claim 33, wherein the controller is configured to adjust resistance applied by the resistance subassembly to constrain the motion of the pedals to a predefined pedal path.

37. The exercise apparatus of claim 36, wherein the controller further includes a display configured to display the predefined pedal path.

38. The exercise apparatus of claim 36, wherein the controller further includes a selector configured to enable a user to select from among a plurality of predefined pedal paths.

39. The exercise apparatus of claim 38, wherein the predefined pedal path is symmetric.

40. The apparatus of claim 39, wherein the predefined path is selected from the group consisting of circular pedal path, elliptical pedal path, parallelogram pedal path, linear pedal path, curvilinear pedal path, vertical pedal path, horizontal pedal path, diagonal pedal path, spiral pedal path, and rectilinear pedal path.

41. The exercise apparatus of claim 1, wherein each of the pedals are adapted to maintain an equal distance from a geometric center.

42. An exercise apparatus, comprising:

a frame;

a pedal support assembly; and

left and right pedals interconnected to the frame by the pedal support assembly and adapted to be moved in any one of the following ways:

(1) in a substantially vertical direction;

(2) in a substantially horizontal direction; and

(3) simultaneously in a substantially vertical direction and a substantially horizontal direction;

wherein the pedal support assembly includes:

a horizontal guide assembly configured to enable the pedals to move in a horizontal direction;

a vertical guide assembly configured to enable the pedals to move in a vertical direction; and

a motion translation mechanism configured to link the pedals to move reciprocally; and

wherein the motion translation mechanism further includes:

a resistance subsystem configured to apply a resistance force to act against the movement of each of the pedals; and

a controller configured to selectively adjust the resistance applied by the resistance subsystem.

43. An exercise apparatus, comprising:
a frame;
a pair of pedals interconnected to the frame;
a horizontal motion translation linkage coupled to each of the pedals
and configured to link the horizontal motion of the pedals; and
a vertical motion translation linkage coupled to each of the pedals
and configured to link the vertical motion of the pedals.

44. An exercise apparatus, comprising:
a frame;
a pedal interconnected to the frame;
a horizontal guide configured to guide horizontal motion of the
pedals; and
a vertical guide configured to guide vertical motion of the pedal.

45. An exercise apparatus, comprising:

a frame;

a pair of pedals interconnected to the frame, the pedals being configured to move within a predefined range of motion; and

a resistance subsystem configured to constrain movement of the pedals to a predefined path within the predefined range of motion.

46. The apparatus of claim 45, wherein the resistance subsystem includes an electromechanical resistance drive.

47. The apparatus of claim 45, wherein the predefined path is selected from the group consisting of circular pedal path, elliptical pedal path, parallelogram pedal path, linear pedal path, curvilinear pedal path, vertical pedal path, horizontal pedal path, diagonal pedal path, spiral pedal path, and rectilinear pedal path.

48. A method of moving pedals on an exercise apparatus, the method comprising:

configuring the pedals for free motion within a predefined range of motion; and

constraining the motion of the pedals to a predefined pedal path within the predefined range of motion via a selectively applied resistance force.

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